A BRIEF ACCOUNT OF SOME OF THE HISTORICAL INSTRUMENTS EXHIBITED AT THE OPTICAL CONVENTION, 1926

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It is obviously impossible within the limits of a short paper to describe all the interesting instruments exhibited ; I, therefore, propose only to touch on a few of those of outstanding importance ; as far as possible, I will take them chronologically.

The first to which I will call attention are the early navigating instruments. Of these we have an early astrolabe supposed to have belonged to the Spanish Armada. It was found in 1845 under a rock on the north side of Combe Hill in the island of Valencia, Co. Kerry, Ireland, within view of the place where three vessels of the Armada were wrecked.

The instrument was made heavy at the bottom so that it would remain steady in the wind ; it was held up by the ring and the swinging arm was rotated until the sun's image, formed through the pinhole in one sight, fell on the other sight. Thus the sun's meridian altitude on that day could be determined, and from that, knowing its declination, the latitude was determined. Another instrument, also used to determine the sun's meridian altitude, was the cross-staff, of which an original example is exhibited (the crosses are restored). The end of the staff was held against the bone at the side of the orbit of the eye and a cross was moved along the staff until its upper end was in line with the sun at the same time that its lower end was in line with the horizon. The staff is graduated to give the angle subtended. This staff is inscribed " Hamon à St. Malo, 1687 ".

There are several quadrants which were also used to obtain either the altitude of the sun or that of one of the brighter fixed stars. The quadrant was held up in a vertical plane and the sun or star sighted through the two pinholes in the sight vanes. While so held, the thumb was placed on the string of the plumb-bob suspended from the top corner of the quadrant, and thus the slope of the edge of the quadrant was found, i.e. the altitude of the star. There is one by Senior, dated 1600, which is interesting as it was made and signed by the designer ; one by Sutton, dated 1660 ; one by T. Wright on a stand—a rather unusual feature ; another, a small astronomical quadrant, by J. Sisson on stand ; a 12-inch one by Bird on a pillar stand, said to have been used by Captain Cook. Many quadrants used to have Gunter's, Sutton's, or other projection on them, and could be used to determine the position of the sun on the ecliptic, to find its time of rising and setting, to find the time of day, the latitude being known, or conversely ; it also gave the position of certain fixed stars so that they could be used in place of the sun.

All these instruments were very difficult to use on board ship owing to the motion of the vessel, and were superseded by the reflecting octant or sextant of Hadley. The principle of this instrument had been suggested by Newton in 1700 but does not appear to have been made use of, and was re-invented and developed by Hadley. Two of these are exhibited, one signed E. Nairne. The older method of subdividing the degree by the use of a nonius persists in this example. It reads to 2′ of arc, but, as usual, the half degrees are numbered as degrees so that the readings shall correspond to the actual altitude without doubling.

Turning now to the more truly optical instruments, I must first call attention to some most interesting examples of a very early English maker Christopher Cocks, viz. a microscope and some telescopes. The microscope is of peculiar interest as being Dr. Hooke's own working microscope. This is one of the instruments that was obtained by Dr. Demainbray for George III, and in the catalogue it is described as " Dr. Hooke's Microscope ". That it was made by the same hand as the telescopes and another microscope was evident both from the similarity of the workmanship and finish, and still more from the gold stampings. Knowing that Cocks had made his microscope for Hooke, and that he was a great telescope maker, Mr. Court came to the conclusion a year ago that all these instruments were by Cocks. This has now been amply confirmed by comparison with W. H. Harper's telescope which is signed by Cocks, and with one another as they have similar construction finish and stampings. Hooke's microscope is the first of which we have a contemporary illustration, and his *Micrographia* (1665), which contains a description of it, together with drawings of a large number of objects observed by him, became deservedly one of the most famous books in every country. There are laudatory foreign references to this microscope and to the English makers of that time in Sturn, Zohn, and elsewhere. The microscope is in a beautiful state of preservation. The body is covered in crimson leather covered with stamped designs in gold, in excellent condition. The mounting is of lignum vitæ, beautifully turned and polished. The snout is of brass and screws into a brass ring carried on an iron pillar 15 inches high. I have no time to say more about this fine and unique instrument, so must refer anyone who wishes further information to a paper by Mr. Court and myself, read before the Royal Microscopic Society on 15th October, 1924.

Contemporary with Cocks in England was a famous microscope and telescope maker in Italy named Campani. Two of his microscopes are on view, both from the Crisp Collection. They contrast strongly with Cocks and with the other English microscopes to which I shall refer in a minute, in their very small size. The eyepiece, in fact, is no larger than that of a modern microscope. They are made of wood, and the workmanship both of the lenses and mounts is excellent. One of these is signed " Campani," the other, which is not signed, is almost certainly by the same maker and probably the older of the two. Both are optically complete.

The next set of instruments to which I wish to refer is the group of Marshall's great double microscopes, of the nine known examples of which no less than five are on view. This is also a most important type of instrument, embodying the fine adjustment screw invented by Hevelius (*Machina Coelestis*, p. 303, *et seq.*), which was afterwards adopted by Cuff, and also attaching both body and stage to an inclining arm, so that the object remained in the optical axis while the inclination was varied. The body was very nearly as large as that of Cocks' ; it was covered with shagreen in the case of three of the microscopes, and with green vellum and gold stampings in that of the fourth. The inner tube is decorated with gold stampings which are all different from those of Cocks and (with one exception) peculiar to Marshall. He usually appears to have supplied six powers, and in some cases, a stage for opaque objects, a fish trough with glass bottom, and a spring stage and condensing lens. Two of the microscopes are signed in the bottom of the drawers " John Marshall Fecit, London," and the one with vellum outer body has the date 1715. There was no mirror ; for transparent objects a candle was placed on the floor and the body turned round to overhang the table, the foot being heavily weighted with lead to enable this to be done with safety.

The Marshall microscope was superseded by that of Culpepper, who mounted his instrument on three legs and added a concave adjustable mirror. His microscope was much easier to make and was extensively copied. A very beautiful example in ivory and tortoiseshell is exhibited. For a full account of this microscope I must refer you to a paper by Mr. Court and myself, read before the Royal Microscopical Society last March. Most of the microscopes of this type, with wooden mounts and shagreen bodies, are either by Culpepper himself or by Matthew Loft, of whose work a signed example in red shagreen is shown. Scarlett, Cuff, Nairne, and Adams also made similar instruments, but examples by these makers are very rare.

Turning back to the simple microscope, we have a most interesting set of Lieberkuhn's microscopes. These were each originally supplied with a mounted object, as Lieberkuhn, like Leeuwenhock, seems to have believed in the motto, one power, one microscope. The microscopes are furnished with a pierced concave mirror to throw the light upon the front of an opaque object. This device has since been identified with Lieberkuhn's name, although it was really invented by Descartes. They have each a single, unmounted magnifying lens. As these have been described many times I will not stop to say more.

One of the most widely known single microscopes was that of J. Wilson, with a screw barrel, described to the Royal Society in 1707. Of these there are an original, unsigned, ivory example of the second form, 1706, a signed ivory one of the third form, and a brass one in black fish-skin case, the two last from the George III collection. There is also a later example, signed

" E. Scarlett ". The screw barrel was later adapted to the solar microscope, and is to be seen on the examples shown, viz., a solar microscope of the first type (nearly all wood with gut gear) and one from the George III collection, of the second type (all brass) signed " John Cuff ". It also appears in the beautiful " Optical Cabinet " by B. Martin, mounted in wood and shagreen.

The Adams Universal, and the improved form made for George III when Prince of Wales, are both most interesting microscopes. The latter will be seen to be mounted on trunnions between which it can be inclined—a fine construction afterwards forgotten, and re-invented by Powell about 1842. Note the curious fine adjustment provided to this microscope. Then there is the beautiful little microscope made by George Lindsey, watchmaker to George II, dated 1742.

I must, however, pass on and draw attention to the exceedingly interesting nineteenth-century microscopes which have belonged to great discoverers. Among these are :—

(1) The historic early achromatic microscope specially made by Plossel of Vienna for Theodor Schwann, the celebrated German physiologist. Schwann was born at Neuss, Prussia, on the 7th December, 1810, and graduated at Berlin in 1834. In 1883 he was called to the chair of anatomy at the University of Louvain, where he remained nine years. In 1847 he went as professor to Liege, where he remained until his death in 1882. His researches on digestion led to the discovery of a substance which he called pepsin. He also examined the whole question of spontaneous generation. But his most notable achievement was his contribution to the cell theory, which was afterwards translated into English under the title of *Microscopic Investigation of the Structure and Growth of Plants and Animals*, 1839. His generalisation became the foundation of modern histology. He bequeathed this microscope to Louvain University, from which the late Sir Frank Crisp purchased it in 1886. On the recent sale of the Crisp Collection it was obtained by its present owner. This instrument has several points of interest :—

(*a*) It is an interesting early achromatic microscope.
(*b*) It is fitted with Amici's horizontal prism so that it can be used horizontally.
(*c*) It has an interesting screw micrometer movement to the stage.
(*d*) The eyepiece is of a special aplanatic construction, and it has a plane glass to the dust cap.
(*e*) The achromatic objectives, of which there are seven, screwed together, can be used singly or in combinations of three, viz., 1 + 2 + 3 or 2 + 3 + 4 and so on.

Considering the early date in which the apparatus was made (about 1835), the performance is quite satisfactory. The whole instrument is beautifully made and finished, and is in a perfect state of preservation. The fine adjustment is effected by a screw at the back of the pillar, which tilts the stage.

(2) The instrument belonged to Ernst Henrich Haeckel, born at Potsdam, 16th February, 1834. He was a pupil of Muller Virchow and Kolliker. He graduated at Berlin, 1857, as M.D. ; in 1862 he was chosen extraordinary professor of comparative anatomy at the University of Jena ; in 1865 he was appointed to the chair of zoology, a position which he retained for forty-three years. He wrote many books on natural history, and was the apostle of Darwinism in Germany. His most popular work was *The Riddle of the Universe,* which appeared in English in 1891. He was a great worker, and by his sixtieth birthday had produced forty-two books, with 13,000 pages. The microscope itself is a very scarce form of Professor Amici's achromatic microscope, made in a portable form which packs into the mahogany case, on to which it screws as a base. The coarse adjustment is effected by sliding the compound body tube up or down in a spring collar.

The fine adjustment is effected by a screw at the back of the square, upright pillar which carries the transverse arm and compound body, and acts on the stage, tilting it up or down. There is a special prism devised by Amici to give illumination both under and over the stage for opaque or transparent objects. It is fitted with four Amici achromatic objectives, and two eyepieces, one of which is achromatic with lenses adjustable to vary their distance from each other. A micrometer is ruled on the surface of the field lens (a feature reintroduced later by Tolles, the well-known American optician). This microscope was purchased from Professor Haeckel by Sir Frank Crisp, through Nachet, the well-known French optician, and at the recent sale of the Crisp collection it was obtained by its present owner.

(3) Zentmayer's Centenial Microscope. This important historical microscope is the actual model that won the Gold Medal at the Paris Exhibition, 1876. It was the first of a series of modern microscopes (1876-1890) in which was introduced a tailpiece that could be swung from side to side, carrying with it the substage and condenser, for the purpose of obtaining the very oblique pencil of light at that time thought necessary to utilise fully the large aperture objective then in use.

(4) The working microscope of Tolles, the celebrated American optician. This instrument is fitted with a very thin stage of a special construction, to be used with a racking and swinging tailpiece, to carry a special form of oblique illuminator. This was intended to obtain and register the angle of the oblique pencils of light thought necessary to utilise the full apertures of the lenses made by him and other opticians of his day. Owing to the extreme thinness of the stage, a certain amount of flexure took place, and it will be observed that in the case of this, his own instrument, in order to strengthen the stage and to give it greater rigidity, Tolles has fitted two steel stayrods, connecting the stage with the limb. This supplies an interesting example of the sort of case where the introduction of a new feature, to provide for a special need, leads to another fault which has to be remedied in turn.

(5) The historical working microscope of Professor P. Harting of the

zoological laboratory of Utrecht, described and figured in his *History of the Microscope,* made for him by Amici about 1830. In addition to the ordinary fittings, there are a binocular body, a double body and a quodriocular body, the last fitted with two special prisms. The extra bodies and the prisms were designed by Harting himself. On his death, Professor Harting bequeathed this microscope to the zoological laboratory of the University of Utrecht. Sir Frank Crisp purchased it from the University authorities in 1886. At the sale of the Crisp collection it was obtained by its present owner. The coarse adjustment is effected by a rack and pinion, and the fine adjustment by a screw at the back acting on the stage. By the adoption of Merz's plan of using a right-angled prism in the middle of the body tube, it could be used horizontally.

(6) Another historical microscope of very interesting design is the original model of the single lever stage microscope designed and made by Cornelius Varley, for which he obtained the Gold Medal of the Society of Arts ; it is described in Vol. 55 of the *Transactions of the Society of Arts.* With the help of this instrument Varley made his observations on the circulation of the sap in chara and other aquatic plants, and drew a large number of plates. His polishing tools and some lenses in course of manufacture are also exhibited, together with the original form of graphic telescope with which he made many portraits of famous men and places.

(7) The first microscope issued under his own name by James Smith. Joseph Jackson Lister, F.R.S., the father of Lord Lister, had been using a microscope of Pritchard's form ; this he had found unsatisfactory, and calling one day on R. B. Bates, the optician in the Poultry, he asked him if he could tell him of a good worker in brass. Bates sent him to James Smith, who was then living in Ironmonger Row, St. Luke's, making microscopes on Pritchard's model for the trade. Under Lister's supervision, but from designs of his own, Smith constructed three stands. He was, however, afraid that he might offend his trade connections if he sold them to private customers, and to avoid this Lister advised him to offer them for sale to his trade customers. Bates, Dixey and Dolland, after inspecting them, all refused, saying that the instruments would not suit their customers, and Smith returned, deeply disappointed. Lister then told him that he must sell the instruments privately, and that he would do all he could for him.

The present instrument was the first to be sold ; it was bought by Richard Low Beck, Lister's partner in the wine trade, and was delivered in 1839. Later, another was bought by a Mr. Alexander of Ipswich. The third was bought on 26th October, 1840, without object glasses, by Joseph Jackson Lister himself, for the sum of £28 19s. 0d., according to an entry in Lister's private ledger in the library of the present owner. From this time James Smith started as a maker under his own name, and Lister instructed him in the grinding of the glasses ; those supplied with this first microscope were designed, if not actually worked, by Lister. Soon after this Beck joined Smith, and that was the beginning of the present firm of Messrs. R. J. Beck. On the 15th April, 1885, this microscope was presented by Joseph Beck to Sir Frank Crisp; in a letter bearing this date he says: " Would you like the microscope relacquered? I think it would be undesirable, it being in very good condition, and shows how, when carefully done by an accomplished workman, as J. Smith undoubtedly was, it will stand hard wear, which in my father's hands it undoubtedly had."

(8) Another important historical telescope is the Gregorian telescope made by the celebrated optician Benjamin Martin at the Globe of Visual Glasses in Fleet, London, *c.* 1760. It was made for Thomas Hancock, Esq., of Boston, Mass., for presentation to Harvard University, for which, according to the records of the University, Hancock was thanked at a meeting in April, 1761. This Thomas Hancock was educated at Harvard, and was a munificent benefactor to his alma mater. His portrait is still preserved there. John Hancock, the great American statesman, one of the first signatories to the Declaration of Independence, was his nephew; and Thomas adopted him and brought him up. It was the sinking of John Hancock's sloop, the " Liberty," by Great Britain that led to the War of Independence. From entries in the University records we know that this telescope, together with other instruments, was lent to Professor Winthorp for use in the expedition to Newfoundland in June, 1761, to observe the transit of the planet Venus over the sun's disc. Winthorp says that he viewed the sun in the reflector on the 5th and 6th June, with great interest, as he hoped to find a satellite of Venus, but in vain.[1] These facts are included by courtesty of the late Professor Edward Pickering of Harvard University. He suggests that during the Revolutionary War the telescope had been carried to England by someone whose sympathy was not with the Americans. On the brass body of the telescope is engraved, " the gift of the Hon. Thomas Hancock of Boston to Harvard University ".

(9) There are three historic objectives :—

(*a*) The one-sixth oil immersion microscope objectives made by Tolles, of Boston, U.S.A., for the late Sir Frank Crisp. This type of objective was the subject of numerous letters, as Tolles claimed for it apertures in excess of those obtainable with dry objectives. A full report by Professor G. G. Stokes and Professor R. Keith, together with Tolles' computation, can be found in the *Journal of the Royal Microscopic Society* for 1878 (pp. 139-43), proving that Tolles' claims were correct.

(*b*) The historical one-fifth objective made by Andrew Ross, the first ever made with a single front of fused quartz. The Rev. W. Kingsley (inventor of the Kingsley sub-stage condenser) says in a note with these objectives: " The 1/5th Ross made with a single front of fused quartz. He came down to Cambridge to show it to me as a step he had made ".

(*c*) A fine one-twelfth objective made by A. Ross for the Rev. W. Kingsley, who in a note with the objective says: " The large angle 1/12th was made expressly for me. Ross had it in hand for three years, and he finished it only shortly before his last illness. He said that the £25 I gave him would not be compensation for the work, and that he would never make another. It is as good as can be."

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[1] *Phil. Trans.* 54 (1764) 279-83.

Before closing, I should like to say how much we, who take an interest in the study of the evolution of scientific instruments from their earlier forms, are indebted to the present organiser of this historical section of the exhibition, Mr. David Baxendall. For many years, in the Science Museum, he has devoted himself to the care, preservation and arrangement of these important links in the history of science; and one has only to contrast the deficiency of the national collection immediately before his appointment, in those sections that have been his especial care, with their comparatively complete condition at the present time, to be conscious of the great work he has done. Very little information about these instruments was available, and it required a large amount of pioneer research to enable him to estimate their importance, and to determine which of those offered to the museum were worthy of a place in the collection. The great part played by these early instruments in the industrial development of the kingdom and of the Empire is now becoming widely recognised. It is, therefore, to be hoped that under his care, and with the aid of his knowledge, the many gaps which still remain will be adequately filled.

Lastly, I must acknowledge my indebtedness to Mr. Thomas H. Court for his invaluable assistance in helping me to compile this report—necessarily all too scanty—dealing as it does with only a few of the large number of instruments exhibited, instruments which, taken as a whole, illustrate once more the large share which England has taken in the development of scientific apparatus.

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